Simplistic approach for Computing Disparity map

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ABSTRACT

In this paper, a simple technique called 'minimum index method' is presented for the computation of disparity map. The Semi Global Block Method is a popular method available in most of the standard computation tools in Matlab. The paper has compared the performance of Semi Global Block Method with the proposed method. The standard method used is the in-build function 'Disparity Map' from the computer vision tool box in MATLAB. In the minimum index method, The Sum Absolute Difference (SAD)is used to find disparity. The right image in input stereo image is shifted column wise depending on the size of disparity. The size of the disparity varies one to sixteen. In the depth map by minimum index method, the minimum disparity occurs in Sum Absolute Difference(SAD) matrix. The simulated results shows that in minimum index method objects in depth map are better recognizable than Semi Global Block method. The mean square error is less in minimum index method than Semi Global Block method.

Keywords: Stereo image, Depth Map and Sum Absolute Difference (SAD)

1. Introduction

The disparity map or depth map is to measure horizontal pixel distance for each pixel coordinate, the horizontal distance between two matching pixels is disparity. The amount of disparity depends on the depth. The depth is difference in distance between two objects and distance to the point of fixation which is known as parallax effect. The same principle is used to find disparities for stereoscopic images.
The stereoscopic images or stereo pair consists of two images of the same scene taken slightly horizontally with separated points from the left view and the right view. The parallax effect also presents stereoscopic images in such a way that objects near the camera will represent more to the right in the left image and more to the left in the right image. The horizontal displacement of an object in the left and right view depends on the distance from the object to the camera viewpoints.
There are various methods to find Disparity map or Depth map. The various methods are Area-based, Feature-based and Global-based methods. The Area and feature based methods are based on intensity profile. The Global methods are based on Bayesian approach that finds disparity as an energy minimization problem. Standard methods of computing disparity is as follows: Method and brief description with reference.
[1] The method used in "Adaptive support -weight approach for correspondence search" is area-based local method to generate depth map or disparity map. The proposed method is based on Gestalt grouping in which support weight is based on similarity and proximity and is proportional to the strength of the grouping. In this method these two values are expressed as a single value in an integrated manner. The group of similarity is calculated by means of Euclidean distance whereas group of proximity is calculated by means of Laplacian Kernel. The weight adoptive method computationally takes longer time than other methods. Method and brief description with reference.
[2] The method used in "A New Approach for Disparity Map Estimation from stereo Image Sequences using Hybrid Segmentation Algorithm" is feature-based local method to generate Depth map or Disparity map. The estimation of Disparity map is by using K-mean square algorithm and hybrid segmentation algorithm. The K means clustering algorithm is used to group the objects based on some criteria; K is a positive integer. The criteria for grouping is by minimizing the distance between data and cluster centroid. Initial set of K, virtual points in the dataspace is randomly selected and every point of data set is assigned the nearest centroid. The position of centroid is updated by means of the data points assigned to the cluster. The algorithm is stopped when the minimum shift is below threshold. The segmentation algorithm extracts feature by Scale Invariant Feature Transform (SIFT) and

Sum of Absolute Difference(SAD).The proposed algorithm is complex and the computation time is higher.
[3] The method used in "A Comparative Study of Energy Minimization Methods for Markov Random Fields" is global based method to generate Depth map or Disparity map. The method used is energy minimization problem on rectangular grid of pixels where energy is expressed as data term and smoothness term. The method used is complex and the computation time is higher. However, all these method do not produce good results or work well for specific types of images We suggest a simple method ensuring a good performance for different kinds of images.
Some application of Depth maps for robot application for navigation purpose and for object recognition to separate occluded image components. Another important scientific application of Depth map or Disparity map is to extract information from aerial surveys and for calculation of contour maps.
The organization of paper is as follows ,the methods used for comparative study is explained in section 2, The results for comparative study is shown in section 3 , Discussion for proposed method in section 4 and the conclusion of the paper in section 5.

2. METHODS USED FOR COMPARATIVE STUDY

The Semi Global Block method and Minimum Index method are used to generate Depth map or Disparity map. The input image is stereo images.
The block diagram shown below indicates methods used for comparative study.

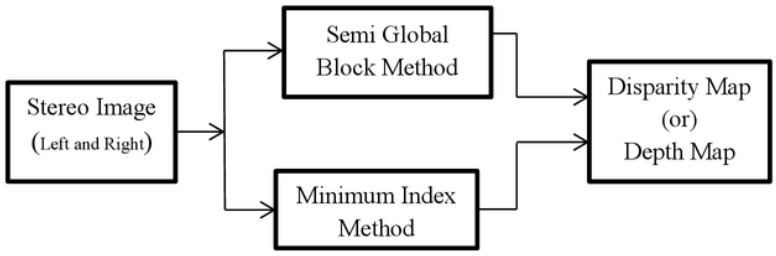

Fig. 1. Disparity Map Comparison Approach .

2.1. Image Rectification for stereo Images

The image rectification is to make the epipolar lines of two camera images aligned horizontally. This can be done by using linear transformations that rotate, translate and skew the camera images.

The principle of image rectification is shown in above figure. The original camera image planes are drawn with solid borders and the rectified image planes are drawn with dashed borders.[6] The epipolar lines are also drawn from the projected points p and p' to epipoles e and e'
After image rectification has been carried out, the epipolar lines of two projected points are parallel and horizontally aligned along the new image planes. The stereo matching problem is therefore reduced to a one dimensional search along horizontal lines instead of a two dimensional search.
Input image referred as a left image corresponding to camera 1 is specified in 2-D grayscale. Input image referred as a right image corresponding to camera 2 is also specified in 2-D gray scale. The Input images left and right must be real, finite, and non sparse. They must be of the same class.

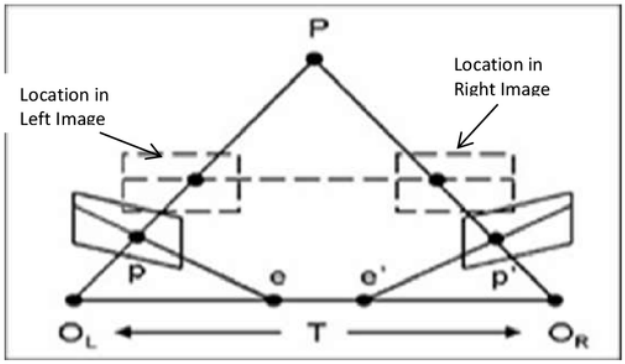

Fig. 2. Conceptual diagram for image rectification.

2.2. Semi Global Block Method

In Semi Global Block method [4],The Disparity map is generated using the computer vision tool box function of MATLAB. The function used from computer vision tool box is 'Disparity map'. The algorithm used to estimate disparity in Semi Global Block method is Semi Global Block matching algorithm. The sum of absolute difference is used to compare each block of pixel in stereo image and Semi Global Block matching algorithm enforces similar disparity to neighbouring blocks.
The Semi Global Block matching algorithm measures the contrast of stereo image by using sobel filter. The Semi Global Block matching algorithm finds the disparity for each pixel in the left stereo image.
In Semi Global Block method, the range of disparity is a two element vector and must be in the format of [Min disparity, Max disparity]. Both elements in disparity range vector must be integers and can be negative. Min disparity and Max disparity must be in the range [-imagewidth, imagewidth]. The difference between Max disparity and Min disparity must be divisible by 16.

2.3. Minimum Index Method

The Sum Of Absolute Difference (SAD) is used in this method. The disparity or label is fixed to 16.The right image is shifted to column wise 1to16,which depends on the size of disparity, then disparity is found where minimum disparity occurs.

2.3.1. Pseudo code for Minimum Index Method

- Left Image = LI of dimension (M X N) = the elements are indicated by =LI(i,j)
- Right Images= RI of dimension (M X N) = the elements are indicated by =RI(i,j)
- for i=1:M
- for j=16:N % Shift of 16 is used to avoid edge-overflow
- E1(i,j)=abs{LI(i,j)-RI(i-1,j)}..... E16(i,j)=abs{LI(i,j)-RI(i-16,j)}
  % E(k) is a vector of 16 elements corresponding to each pixel values.
  %Difference in pixel value is computed for all 16 steps
- D(i,j)= min(E1(i,j),E2(i,j),E3(i,j).....E16(i,j))
  % The disparity value is decided where, minimum difference in pixel values is observed.
  % In other words,if $E(5)_{i,j}$ is the minimum value of $E(k)_{i,j}$ then D(i,j)= 5.

- end
- end

3. SIMULATED RESULTS

The stereo images for testing are from data sets 2014 of Middlebury computer vision website (vision.middlebury.edu). Baby, Bowling, Cloth and Pot are considered as test stereo images and these images have ground truth.

Table 1. Dimension and size of Input stereo image and reference (ground truth) image.

Image Type	Stereo Left Image	Stereo Right Image	Ground Truth Left	Ground Truth Right
Baby	437X370 (230kb)	437X370 (229kb)	437X370 (18.5kb)	437X370 (18.7kb)
Blowing	443X370 (235kb)	443X370 (230kb)	443X370 (21.2kb)	443X370 (21.4kb)
Cloth	433X370 (315kb)	433X370 (320kb)	433X370 (19.8kb)	433X370 (20.6kb)
Pot	437X370 (189kb)	437X370 (188kb)	437X370 (20kb)	437X370 (20.5kb)

Table 2. Mean Square Error for both methods for test images.

Stereo Image	Minimum Index Method(MSE)	Standard Method(MSE)
Baby	2150	16950
Bowling	3074	19526
Cloth	2177	20137
Pot	3143	17229

Table 3. Dimension and Run time of Depth Map by Minimum Index Method.

Test Image	Size of Depth Map	Run time
Baby	611 X 465(93.4KB)	10.5sec
Blowing	617 X 465(93.5KB)	1.4 sec
Cloth	607 X 465(110KB)	1.68sec
Pot	611 X 465(76.8KB)	1.68sec

4. DISCUSSION

The performance comparison was done subjectively by human perception as well as by computation of mean squared error with the ground reality image. The Depth map for different test stereo image by both methods (Semi Global Method and Minimum Index method) are shown in Fig.3.
Details of test stereo images and reference (ground truth) images are shown in table 1
We have found that the proposed method for Baby and Bowling test stereo image gives 7 times, Cloth test stereo image 10 times and Pot test stereo image 6 times less Mean Square Error(MSE) as compared to Semi Global Methods which is shown in table 2.
The run time for both methods computed on a system Intel(R) Core(TM) i5-4200M CPU @2.5GHz using MATLAB Version 15.The size of depth map obtained by Minimum Index Method and Semi Global Block method for different test stereo images with run time shown in table 3 &table 4 respectively.

5. CONCLUSION

In this paper, we have proposed a new method to generate Depth map using Sum Of Absolute Difference (SAD) for stereo images. The Depth map by proposed minimum index method is compared with Semi Global Block

Table 4. Dimension and Run time of Depth Map by Semi Global Block Method.

Test Image	Size of Depth Map	Run time
Baby	611X465(20.6KB)	0.82 sec
Blowing	617 X 465(15.8KB)	0.7sec
Cloth	607 X 465(8.5KB)	0.73sec
Pot	611 X 465(13.3KB)	1.02sec

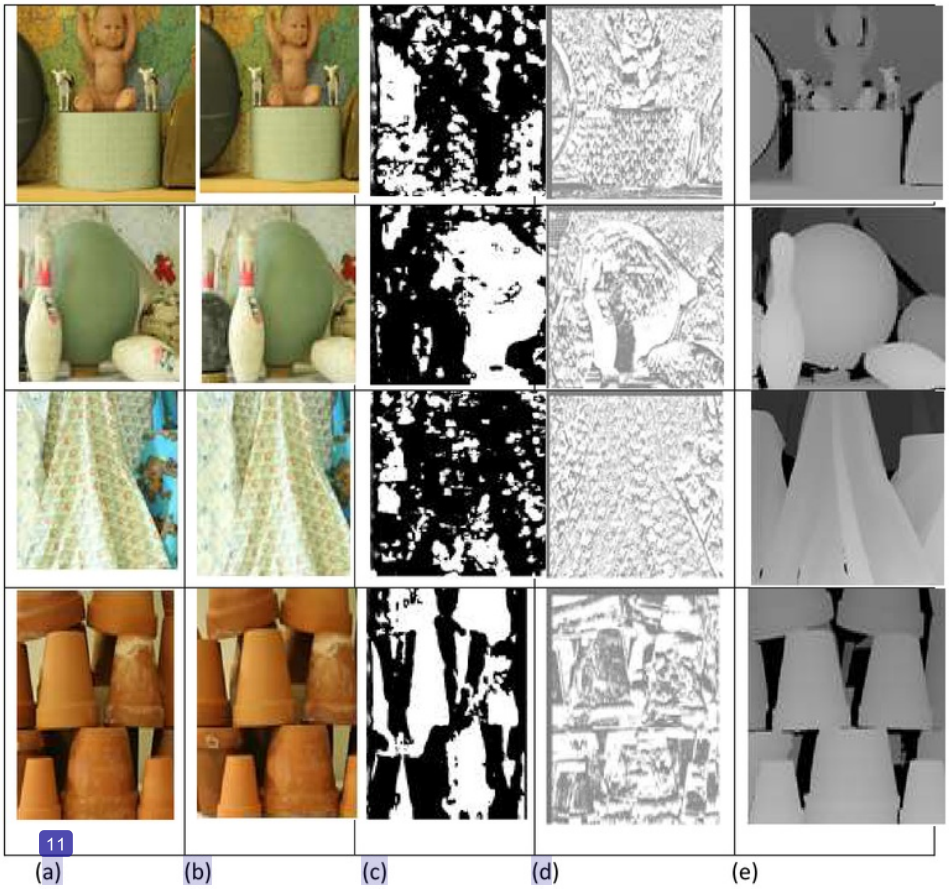

Fig. 3. Stereo input images and Depth maps(a) Left Image (b) Right Image (c) Depth map by Semi Global Block method (d) Depth map by Minimum Index Method (e) Ground truth.

method.
The Semi Global Block method recovers Depth map using MATLAB in build function 'Disparity Map' from computer vision tool box.
The proposed method shows much better agreement with the 'ground truth image', when compared with 'Semi Global Block' method available as a standard utility in MatLab. It takes marginally more computation time across different types of images that, objects in Depth map as comparable to ground truth image whereas in Semi Global Block method it is difficult to identify objects in Depth map.
The runtime for both methods are almost same but Mean Square Error (MSE) is less in Minimum Index method than Semi Global Block method for all test stereo images. With this performance Minimum Index method has can be used as generic method.

5.1. FUTURE WORK

The Initial Depth Map generated by Minimum Index Method and Semi Global Block method can be improved by using optimization algorithm like Graph cut and Belief Propagation.

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6. BIOGRAPHY

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